Some Performance Comparisons between US and European Airports

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October 29, 2009

(based on work with SM thesis student Thomas Morisset)

Outline

- Background
  - Project description
  - Outline of approach
- Conclusions
  - Capacity effects
  - Delay effects
  - Schedule reliability effects
  - Future needs

The Project

- Some comparisons of performance characteristics: European vs. US Airports
- Sponsored by FAA and Eurocontrol (ongoing) as part of an extensive inquiry
- 34 top airports in Europe vs. 34 top in US
- Effect of

(i) use of VMC procedures, weather permitting, at US airports

(ii) limited or, mostly, non-use of declared capacity limits at US airports

on the performance of US vs. European airports w.r.t. capacity, delays and reliability of schedule

Declared Capacity

- **Definition: A declared limit on the number of aircraft movements that can be scheduled per unit of time (typically one hour) at an airport**
- **Specifies the number of available "slots" to be allocated through the "slot coordination" process**
- **The declared capacity is determined by the most "constraining" element of the airport (runways, taxiways, apron, terminal complex, landside)**
- **With the exception of some small airports, the runway system is typically the most constraining element**

Rk	City	Ctry	Code	Rwy	Group	Movnts	Pass	Cargo	Declared capacity (Eurocontrol)
1	Paris CDG	FR	CDG	4	E	552,721	59,919,383	2,005,160	112
2	Frankfurt	DE	FRA	3	-	492,569	54,161,856	2,169,025	75-83
3	Madrid	ES	MAD	4	-	483,284	52,122,214	356,427	90
4	London Heathrow	GB	LHT	2	D	481,356	68,068,554	1,395,909	89
5	Amsterdam	NL	AMS	6	-	454,357	47,793,602	1,651,385	106
6	Munich	DE	MUC	2	D	431,815	33,959,422	265,607	90
7	Barcelona	ES	BCN	3	-	352,489	32,793,897	100,360	61
8	Rome	IT	FCO	4	-	334,848	32,855,542	154,439	88
9	Vienna	AT	VIE	2	-	280,915	18,768,468	205,045	66
10	Zurich	CH	ZRH	3	-	268,537	20,686,986	290,653	68
11	Milan	IT	MXP	2	C	267,825	23,885,305	486,169	69
12	London Gatwick	GB	LGW	1	A	266,495	35,218,399	176,807	50
13	Brussels	BE	BRU	3	D	264,366	17,838,689	728,689	74
14	Istanbul	TR	IST	3	-	262,248	25,561,357	341,514	
15	Copenhagen	DK	CPH	3	-	257,591	21,356,134	380,024	83
16	Paris Orly	FR	ORY	3	-	236,926	26,440,736	94,920	72
17	Dusseldorf	DE	DUS	2	B	227,897	17,831,248	58,026	33-47
18	Oslo	MO	OSL	2	D	226,232	19,044,011	97,310	
19	Manchester	GB	MAN	2	B	222,669	22,362,050	166,438	59
20	Stockholm	SE	ARN	3	-	218,549	17,968,023	122,922	
21	Dublin	IE	DUB	2	A	211,803	23,289,417	107,921	46
22	London Stansted	GB	STN	1	A	208,601	23,777,194	228,759	
23	Athens	GR	ATH	2	D	205,294	16,522,680	118,959	60
24	Palma de Mallorca	ES	PMI	2	D	197,354	23,223,963	26,408	60
25	Nice	FR	NCE	2	-	190,076	10,399,570	11,545	
26	Geneva	CH	GVA	1	A	190,008	10,807,060	36,750	
27	Helsinki	FI	HEL	3	D	184,052	12,956,754	139,328	80
28	Prague	CZ	PRG	3	-	174,662	12,478,078	55,376	44
29	Hamburg	DE	HAM	2	-	173,513	12,780,504	86,997	53
30	Stuttgart	DE	STR	1	A	167,264	10,321,431	29,278	42
31	Warsaw	PL	WAW	2	-	153,476	9,268,476	63,126	
32	Berlin	DE	TXL	1	A	151,396	13,357,741	20,870	48
33	Cologne	DE	CGN	3	-	151,020	10,471,657	710,244	36-52
34	Lisbon	PT	LIS	2	-	144,797	13,392,131	94,693	36

Rk	City	Ctry	Code	Rwy	Group	Movnts	Passengers	Cargo	Opt cap	Marg cap	IFR cap
1	Atlanta (*05/26/06*)	GA	ATL	4	E	980,386	85,907,423	767,897	180-188	172-174	158-162
2	Chicago O'Hare	IL	ORD	7	-	927,834	76,159,324	1,524,419	190-200	190-200	136-144
3	Dallas	TX	DFW	7	-	684,779	59,784,876	724,957	270-279	231-252	186-193
4	Los Angeles	CA	LAX	4	E	681,445	61,895,548	1,877,876	137-148	126-132	117-124
5	Denver	CO	DEN	6	-	614,169	49,863,389	260,287	210-219	186-202	159-162
6	Las Vegas	NV	LAS	4	-	609,472	47,595,140	91,688	102-113	77-82	70-70
7	Houston	TX	IAH	5	-	603,836	42,978,617	410,632	120-143	120-141	108-112
8	Phoenix	AZ	PHX	3	-	538,063	42,197,080	256,817	128-150	108-118	108-118
9	Charlotte	NC	CLT	3	D	522,541	33,383,812	139,693	130-131	125-131	102-110
10	Philadelphia	PA	PHL	4	-	498,963	32,207,709	543,450	104-116	96-102	96-96
11	Detroit	MI	DTW	6	-	467,230	36,126,555	223,379	184-189	168-173	136-145
12	Minneapolis - St Paul	MN	MSP	4	-	450,337	35,160,505	249,759	114-120	112-115	112-114
13	Newark	NJ	EWR	3	-	443,952	36,391,911	943,174	84-92	80-81	61-66
14	New York JFK	NY	JFK	4	-	443,004	47,810,630	1,595,577	75-87	75-87	64-67
15	Salt Lake City	UT	SLC	4	-	414,395	22,029,488	117,686	130-131	110-120	110-113
16	Boston	MA	BOS	6	-	399,537	28,088,855	298,046	123-131	112-117	90-93
17	New York La Guardia	NY	LGA	2	-	389,492	24,940,818	10,659	78-85	74-84	69-74
18	Miami	FL	MIA	4	-	386,981	33,740,416	1,922,982	116-121	104-118	92-96
19	Wahington Dulles	DC	IAD	4	-	382,907	24,494,999	358,526	135-135	114-120	105-113
20	San Francisco	CA	SFO	4	-	379,500	35,793,117	560,501	105-110	81-93	68-72
21	Memphis	TN	MEM	4	-	374,989	10,853,698	3,840,574	148-181	140-167	120-132
22	Orlando	FL	MCO	4	E	359,101	36,385,300	196,771	144-164	132-144	104-117
23	Seattle (*Nov 08*)	WA	SEA	2	B	346,073	31,303,220	319,582	80-84	74-76	57-60
24	Cincinnati	OH	CVG	4	-	320,449	15,734,322	39,546	120-125	120-124	102-120
25	Fort Lauderdale	FL	FLL	3	-	307,975	22,681,903	137,219	60-62	60-61	52-56
26	Chicago Midway	IL	MDW	5	-	304,657	19,378,546	13,482	64-65	64-65	61-64
27	Baltimore-Washington	MD	BWI	4	-	296,870	21,497,555	115,323	106-120	80-93	60-71
28	Washington Reagan	DC	DCA	3	-	275,433	18,670,924	2,515	72-87	60-84	48-70
29	Portland	OR	PDX	3	C	264,518	14,654,222	254,744	116-120	79-80	77-80
30	Cleveland	OH	CLE	5	-	259,471	11,447,011	86,642	80-80	72-77	64-64
31	Tampa	FL	TPA	3	D	258,349	19,154,957	97,547	102-105	90-95	74-75
32	St Louis	MO	STL	6	-	254,302	15,366,198	83,356	104-113	91-96	64-70
33	San Diego	CA	SAN	1	A	228,902	18,326,761	140,308	56-58	56-58	48-50
34	Pittsburgh	PA	PIT	4	-	209,303	9,821,980	84,266	152-160	143-150	119-150

Methodology

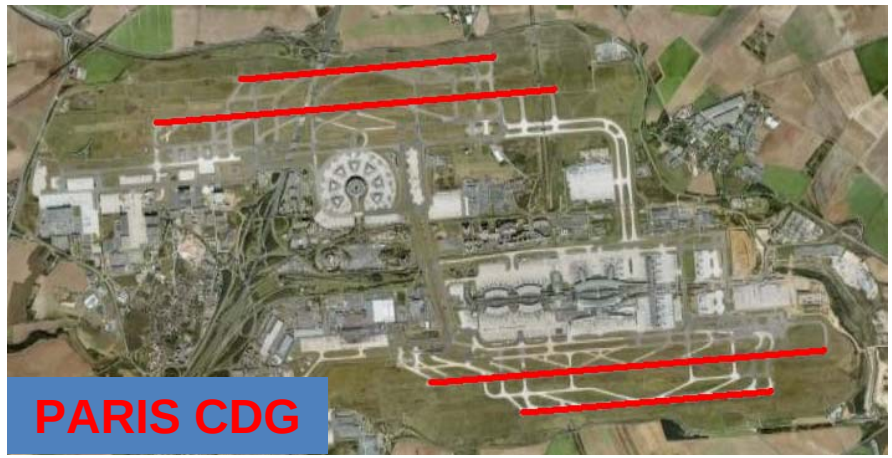
- Extensive data analysis
  - U. of Aachen study of European airports (ongoing)
  - ASPM database (FAA)
  - CODA database (Eurocontrol)
- Capacity and delay modeling, especially for European and US airports with similar runway system layouts
  - MACAD: model to compute airport capacity
  - DELAYS: stochastic and dynamic model to compute delays at individual airports
  - AND: model to compute the propagation of delays in a large network of airports

E – Two pairs of close // runways

LOS ANGELES

ATLANTA

+ ORLANDO ?



PARIS CDG

Distance between parallel runways:

LAX: 700 and 800 ft
ATL: 1000 and 1050 ft
MCO: 1500 ft (between close pair)

CDG: 1260 ft

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  - **Delay effects**
  - **Schedule reliability effects**
  - **Fundamental needs**

Some "Macro" Indicators : Top 34 European vs. Top 34 US Airports

	USA	Europe
Average no. of annual movements (thousand)	**438** (+64%)	**267**
Average no. of annual passengers (millions)	**33.0** (+32%)	**25.0**
Passengers per movement	**75.4**	**93.8** (+24.4)
Average no. of runways per airport	**4.12** (+67%)	**2.47**
Annual movements per runway (thousand)	**106.3**	**108.1** (+1.7%)

Averages for 15 Busiest Airports (2007)

Busiest 15 Airports	Millions of Annual Passengers (average)	Thousands of annual aircraft movements (average)	Passengers per movement
United States	53.1	642	83
Europe	37.2 (-30%)	348 (-46%)	107 (+29%)
Asia/Pacific	35.8 (-33%)	234 (-64%)	153 (+84%)

Principal Conclusions [1]

- **No standard methodology for determining declared capacity**
  - **some sophisticated approaches with detailed simulations and extensive consultation with stakeholders**
  - **many *ad hoc*, "back-of-the-envelope" approaches with limited inputs and "politicized" considerations**
- **Declared capacities in Europe are set with reference to IFR capacities of the airport:**
  - **Lower than IFR capacities in most cases (MUCH lower in some)**
  - **Very close to (and sometimes slightly above) estimated IFR capacities at some of the busiest airports (e.g., Heathrow, Frankfurt, Gatwick, Munich)**
- **Slot limits (when they exist) in the US are set with reference to VMC capacities; at busy airports airlines seem to schedule hourly runway movements with reference to VMC capacities**

Principal Conclusions [2]

- VMC procedures are used for a very high fraction of time in US
  - 84% of all movements in 2008;
  - Range from low of 64% (Seattle) to high of 99% (Las Vegas)
  - Provide, on average, a 21% gain in overall capacity over IFR capacity at the 34 US airports
- As a result, declared capacities (or the capacities assumed for airline scheduling purposes) in US are significantly higher than in Europe (and Asia)
  - Can be clearly demonstrated for airports with similar layouts of runways

Capacity Comparisons [1]

	US max throughput capacities*				EU declared capacities**	
FAM	Airport	IFR	marg	optim	Airport	DC
A	San Diego	48-50	56-58	56-58	Gatwick Dublin Berlin Stuttgart Stansted	50 46 48 42 --
B	Seattle	57-60	74-76	80-84	Manchester Dusseldorf	59 47
E	Atlanta Los Angeles Orlando	158 - 162 117-124 104 -117	172 - 174 126 - 132 132 - 144	180 - 188 137 - 148 144 - 164	Paris	112

Overall capacity = (0.8)(57)+(0.2)(49) = 56

O.C. = 76

O.C.: ATL = 179; LAX = 137; MCO = 150

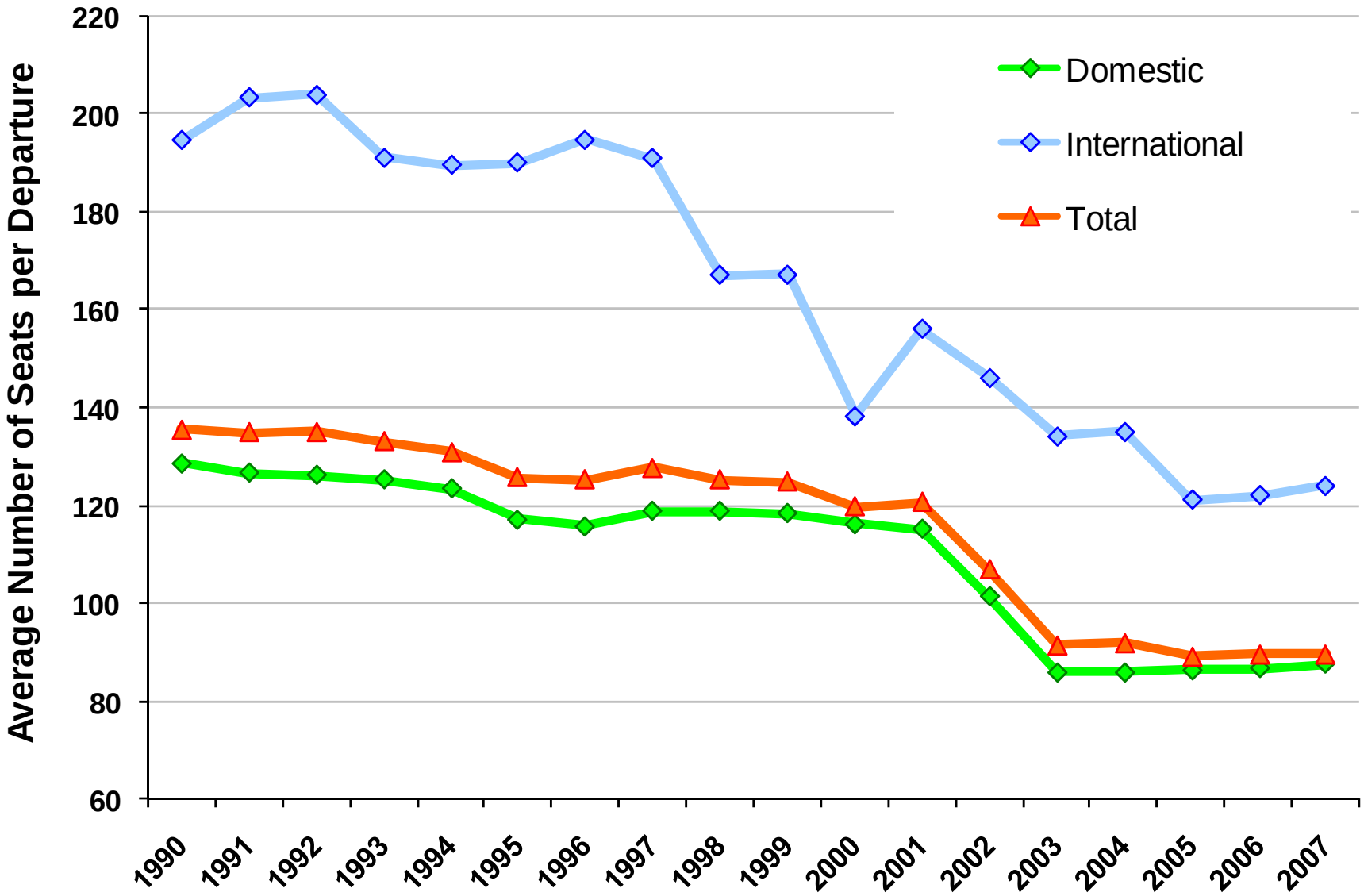
*Source: FAA 2004 Benchmark report

**Source: Eurocontrol

Principal Conclusions [3]

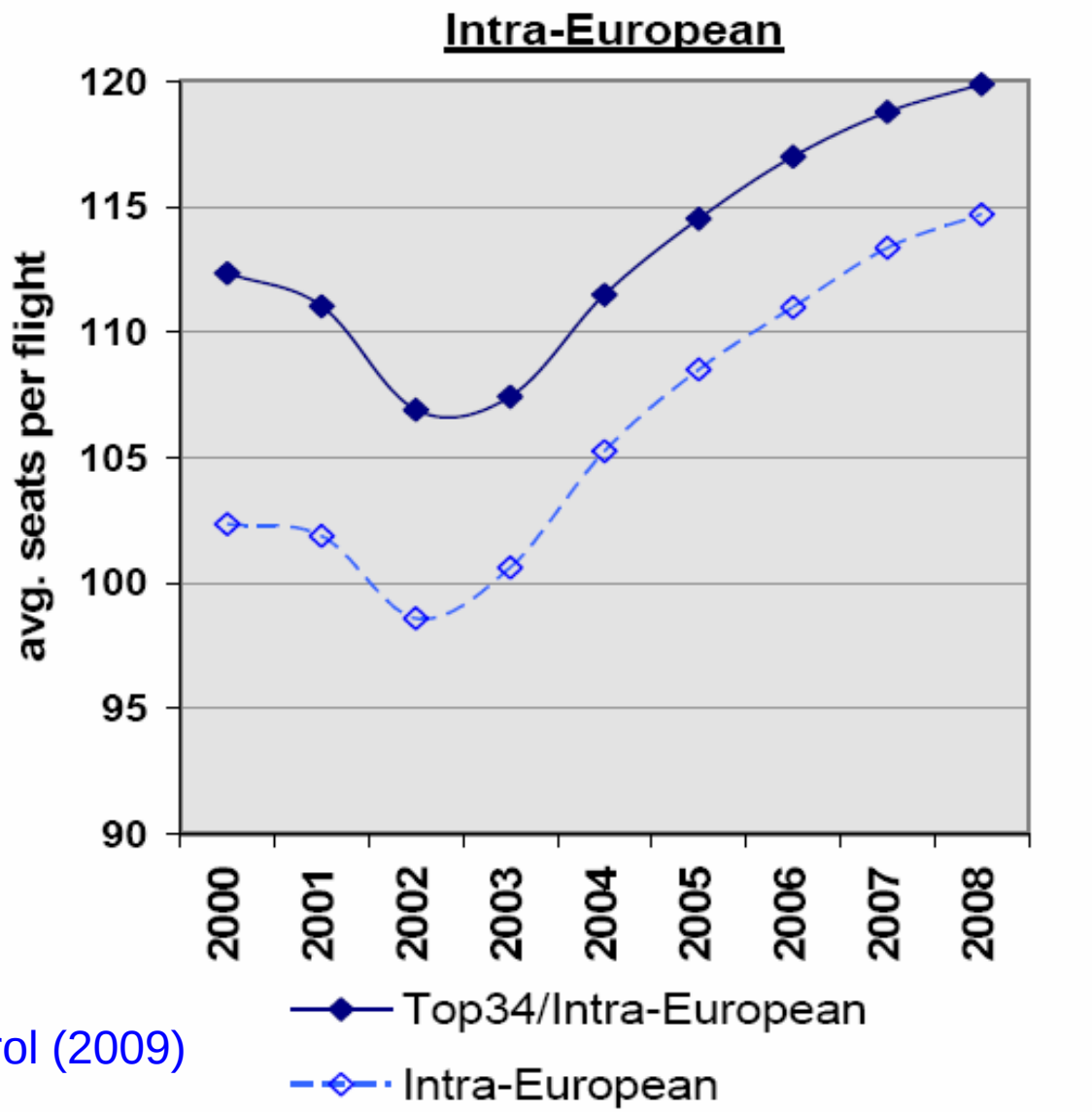
- By not using VMC procedures, when weather permits, European airports may be sacrificing significant potential additional capacity
- The actual operational capacity of airports exhibits
  - Great variability with weather conditions in US
  - Limited variability with weather conditions in Europe
- By "inviting" large numbers of movements, US airports achieve very high volumes of traffic, as measured by number of aircraft movements
- But, in practice, this has led to competition w.r.t. frequency of service and to smaller average aircraft size

Average No. of Seats Per Departure: USA



Source: Bonnefoy and Hansman (2008)

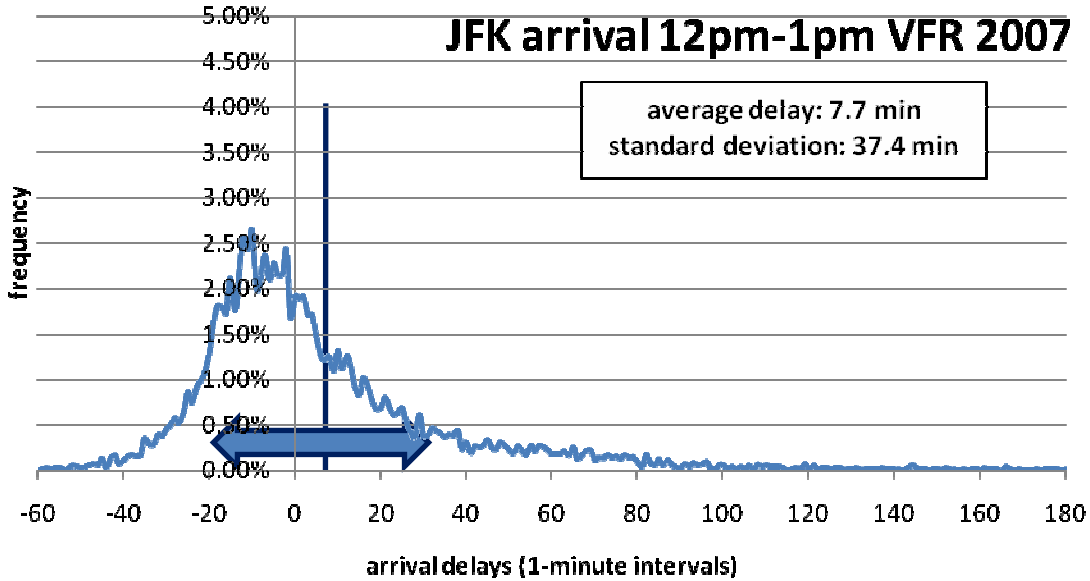
Ave. No. of Seats per Departure: Europe

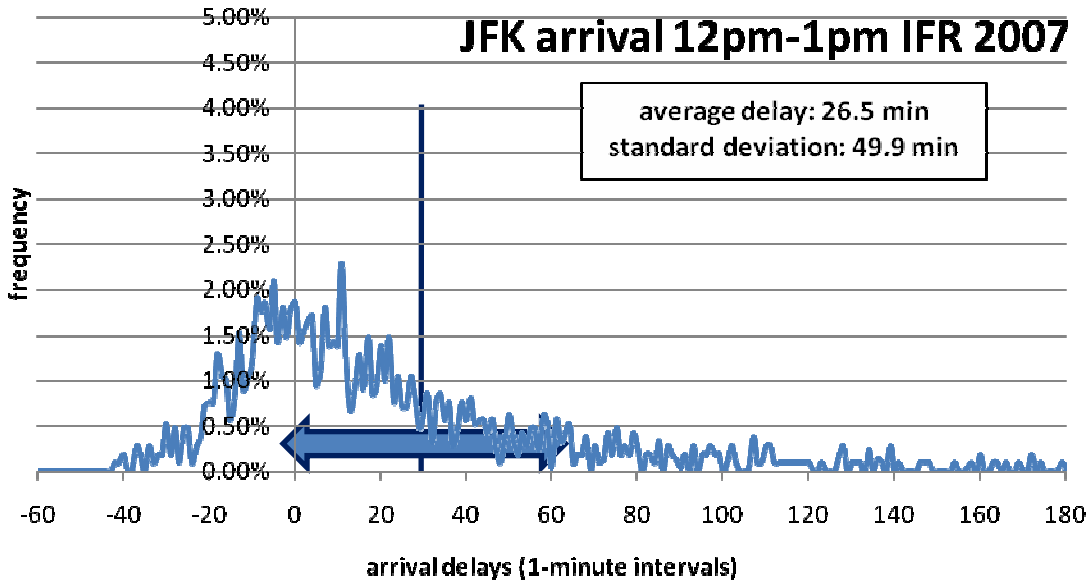


Source: Eurocontrol (2009)

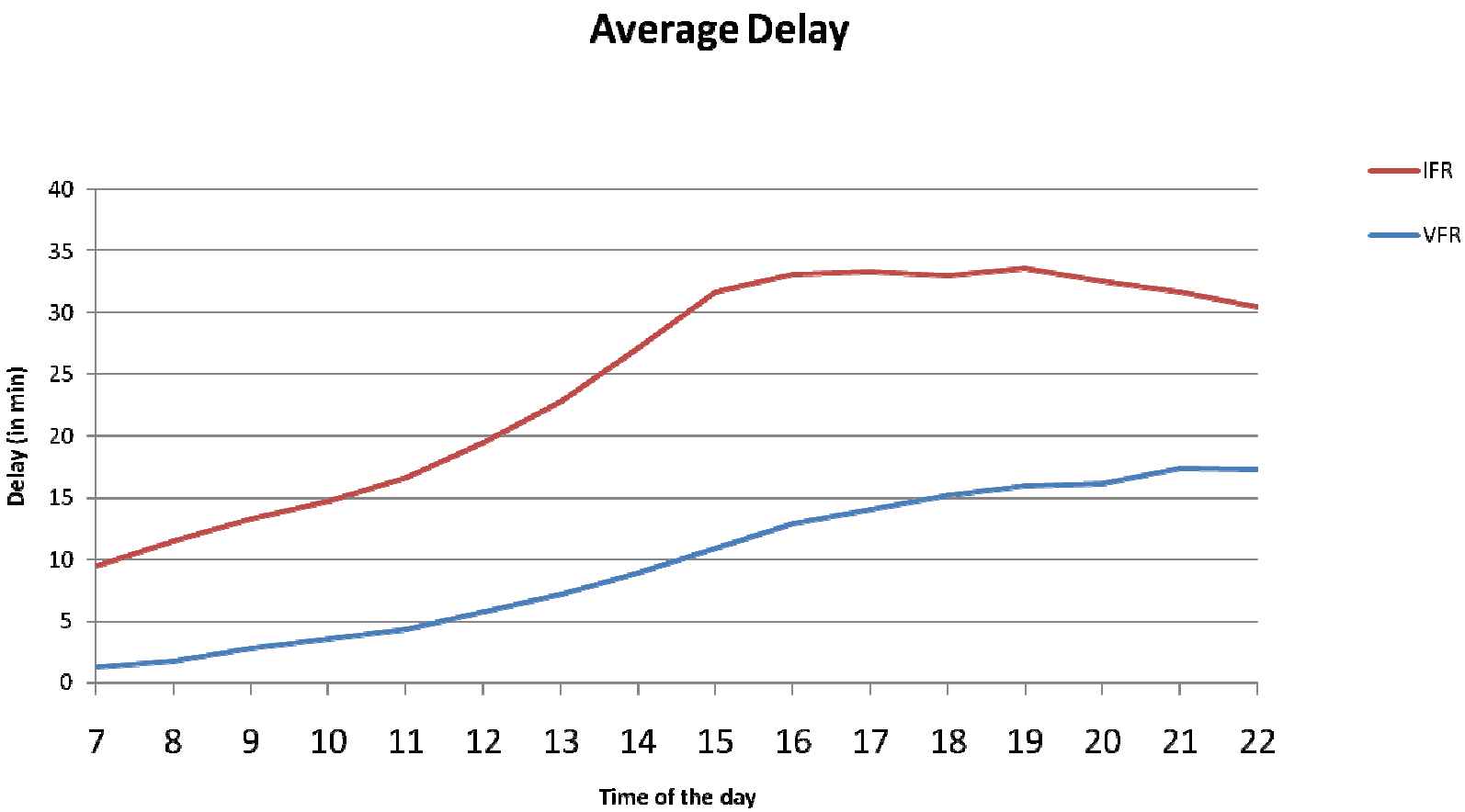
Principal Conclusions [4]

- **Delays (relative to schedule) in US are very high on average in IMC**
  - **Average arrival delay for 34 airports in 2007:**
    - **9 min in VMC vs. 23 min in IMC [plus cancellations]**
- **Schedule reliability is much lower in the US than in Europe (larger expected value and standard deviation of delay relative to schedule in US)**
- **Reliability of schedules in US declines over the course of a day, particularly in the presence of poor weather**
- **In defense, US airlines have been increasing (up to 2007) the advertised flight durations; European airlines have not**
- ***Caveat:* A large part of schedule unreliability may be due to factors other than air traffic congestion**


JFK arrival 12pm-1pm VFR 2007
average delay: 7.7 min
standard deviation: 37.4 min
frequency
5.00%
4.50%
4.00%
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
-60 -40 -20 0 20 40 60 80 100 120 140 160 180
arrival delays (1-minute intervals)


JFK arrival 12pm-1pm IFR 2007
average delay: 26.5 min
standard deviation: 49.9 min
frequency
5.00%
4.50%
4.00%
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
-60 -40 -20 0 20 40 60 80 100 120 140 160 180
arrival delays (1-minute intervals)

Delay Relative to Schedule: 34 Airports (All Arrivals, 2007)



Principal Conclusions [4]

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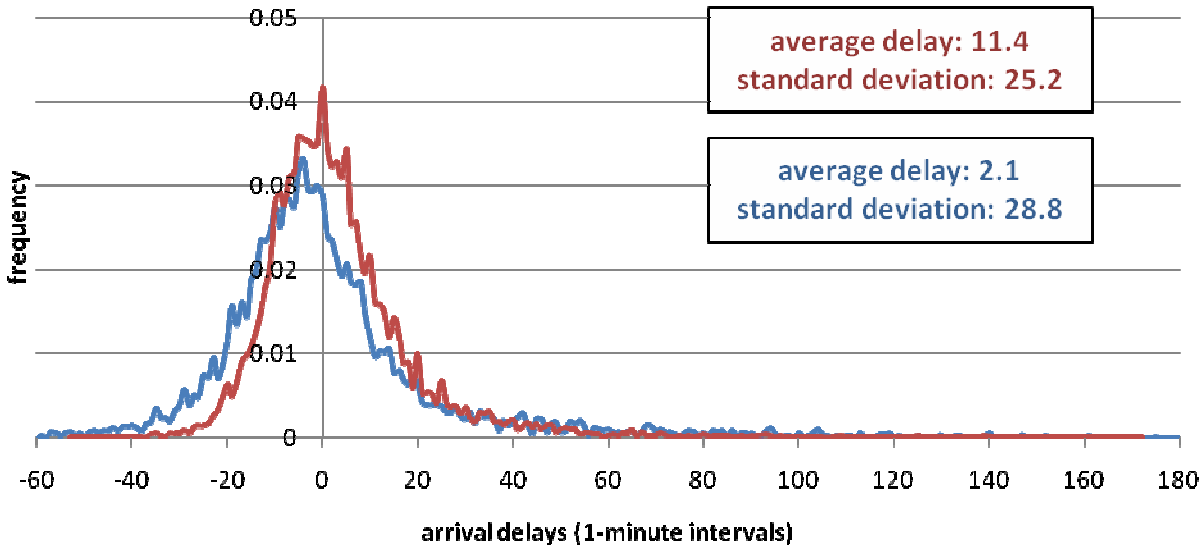
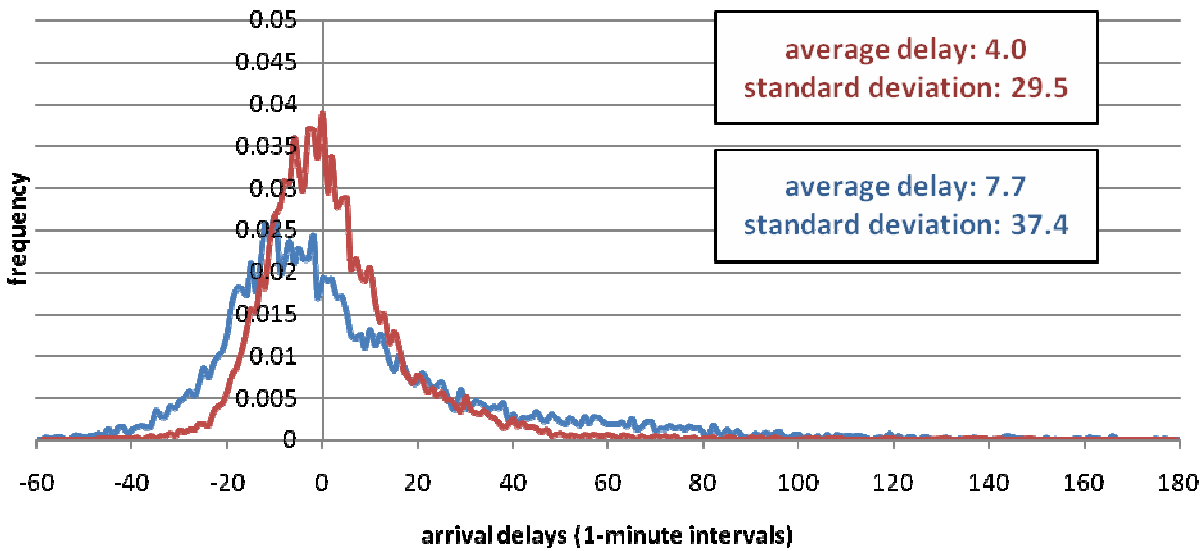
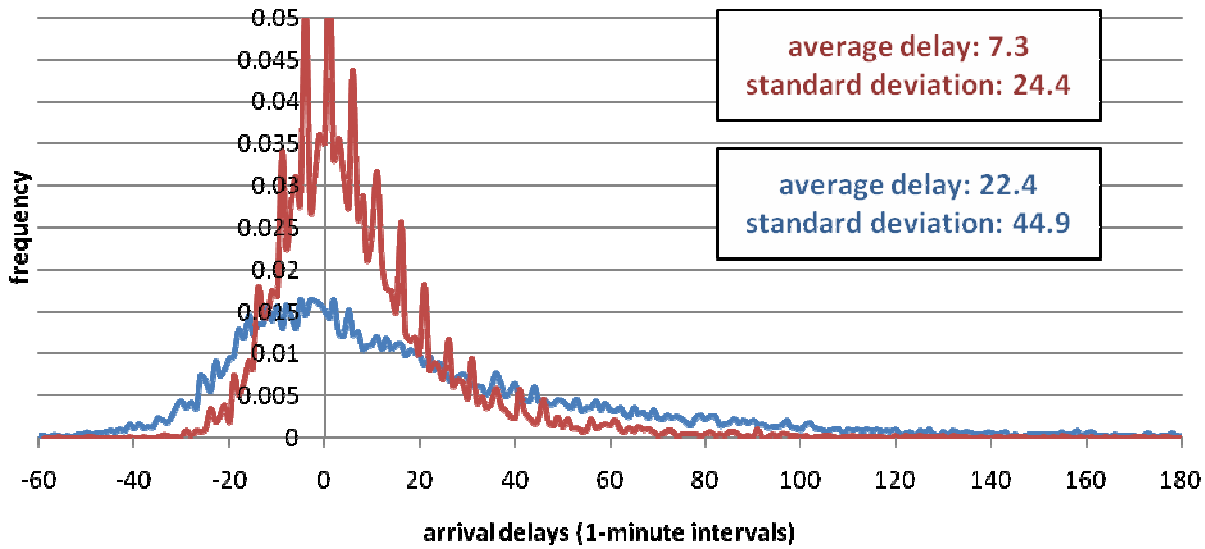
CDG v. JFK arrival 8am-9am 2007



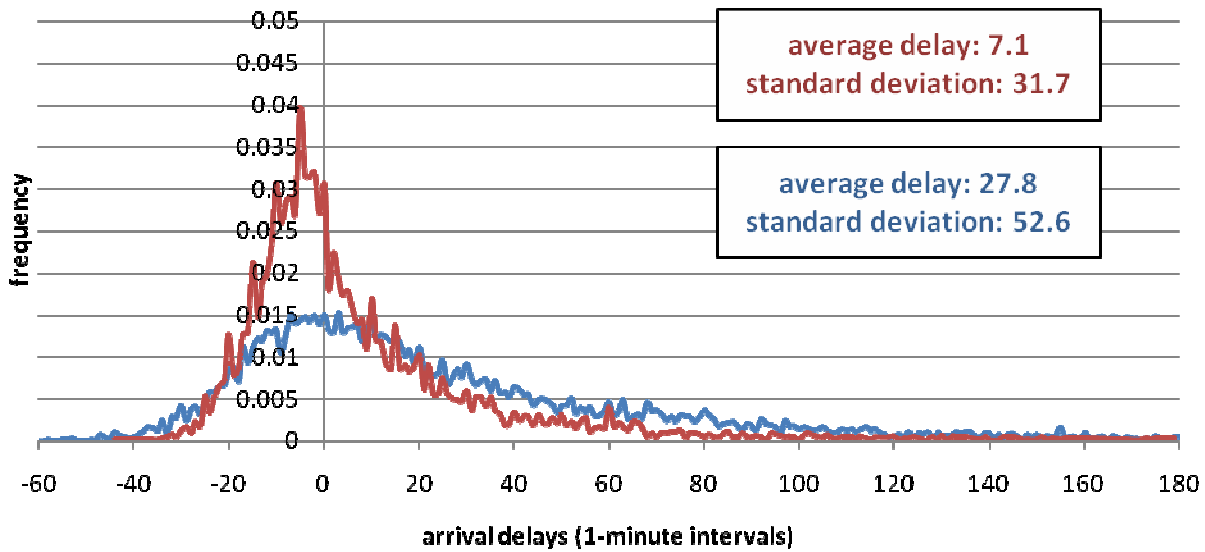
CDG v. JFK arrival 12pm-1pm 2007



CDG v. JFK arrival 4pm-5pm 2007



CDG v. JFK arrival 8pm-9pm 2007



Details by airport

- We rank below all 68 airports according to the difference between average delay at 7pm and average delay at 8am
- Average difference: US ➔ 14.2 min, EUR ➔ 3.9 min!
- Of the 28 airports with largest difference, 27 are in US (LHR being the only exception)!

EWR	33.2
JFK	27.4
LGA	26.3
ORD	20.3
PHL	17.9
MIA	17.6
FLL	17.5
DCA	17.0
BOS	16.7
ATL	16.5
MDW	15.1
BWI	14.8
T34 US	14.2
TPA	14.2

DEN	14.1
MCO	14.0
MEM	13.2
SEA	12.8
CLE	12.5
SFO	12.3
PIT	11.2
LAS	11.1
STL	10.5
LHR	10.5
DFW	10.5
LAX	10.3
SAN	10.1
PHX	10.0

IAH	9.0
CLT	8.8
PMI	8.8
SLC	8.8
GVA	8.6
LIS	8.6
PDX	7.5
PRG	7.5
CVG	7.2
AMS	7.0
IST	7.0
FCO	6.9
LGW	6.7
MXP	6.6

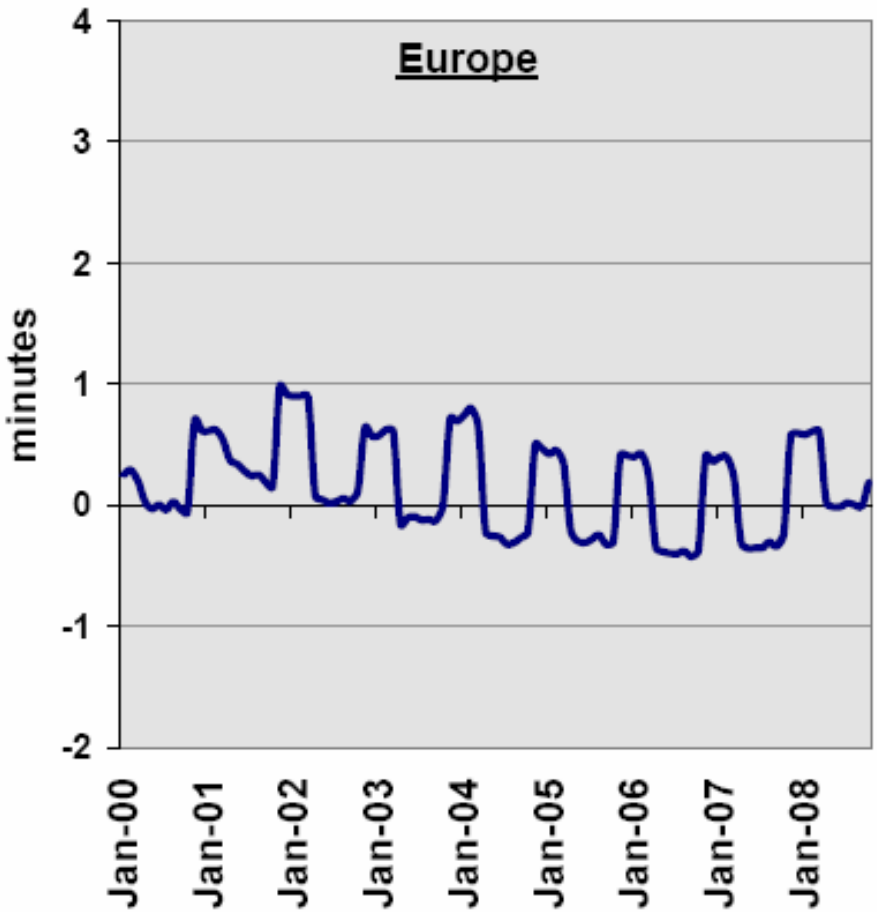
DUB	6.6
ORY	6.6
DTW	6.4
MSP	6.3
CPH	6.2
MAD	6.1
STN	6.1
BCN	6.0
ARN	5.8
MAN	5.2
IAD	4.9
TXL	4.9
BRU	4.3
T34 EUR	3.9

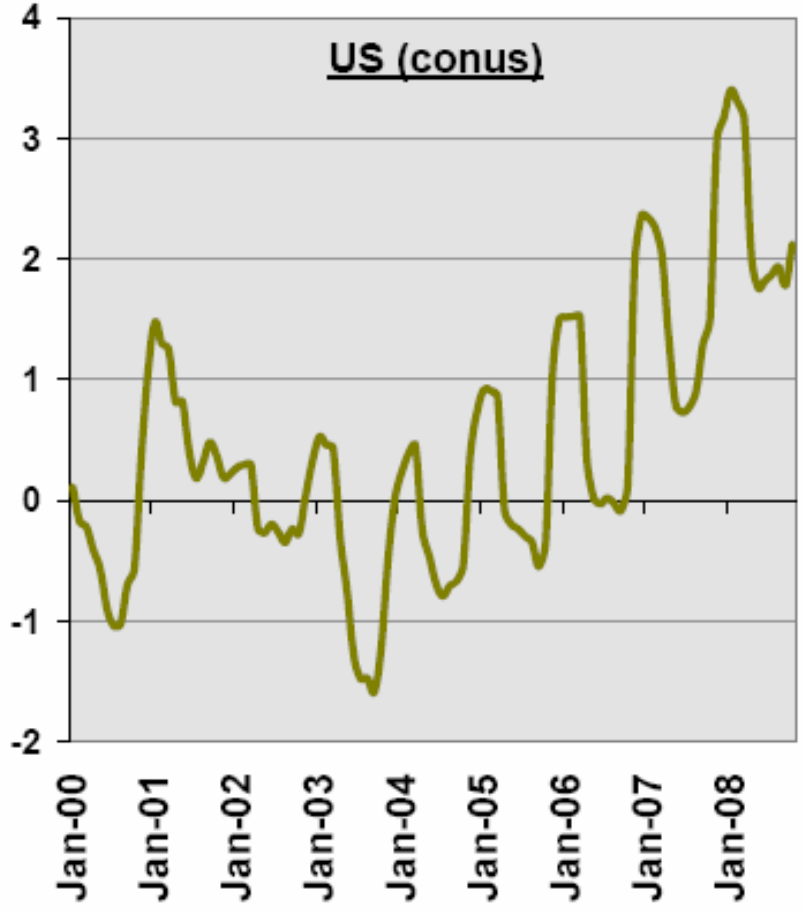
HAM	3.7
OSL	3.0
MUC	2.6
ATH	2.5
CGN	1.6
DUS	1.4
STR	1.3
WAW	0.6
FRA	0.1
HEL	-0.1
NCE	-0.1
ZRH	-1.5
CDG	-3.6
VIE	-5.5

Principal Conclusions [4]

- **Delays (relative to schedule) in US are very high on average in IMC**
  - **Average arrival delay for 34 airports in 2007:**
    - **9 min in VMC vs. 23 min in IMC [plus cancellations]**
- **Schedule reliability is much lower in the US than in Europe (larger expected value and standard deviation of delay relative to schedule in US)**
- **Reliability of schedules in US declines over the course of a day, particularly in the presence of poor weather**
- **In defense, US airlines have been increasing (up to 2007) the advertised flight durations; European airlines have not**
- ***Caveat:* A large part of schedule unreliability may be due to factors other than air traffic congestion**

Evolution of Scheduled Block Times
(34 top airports)





Source: FAA/Eurocontrol (2009)

In Simplified Summary…

- US airports place a premium on full utilization of all potential capacity, including stretching capacity in VMC
- Benefit: high volume of air traffic processed
- Risks: large delays, high sensitivity to weather, poor schedule reliability, (?) excessive no. of flights
- European airports place a premium on predictability and "smoothing" operations, relying on (often too low) declared capacities* and IFR separations at all times
- Benefit: much lower incidence of capacity-induced extreme delays; far more predictable schedule performance
- Risk: low utilization of valuable capacity; may not be "pushing the envelope" sufficiently at some airports

**The methodology for allocating slots is the topic of a continuing debate, but lies outside the scope of our study*

An Important Global Requirement

- Thoughtful, common, transparent, model-supported methodology for determining "declared capacity"
- Best practice today is at UK NATS [estimation of declared capacity of London Heathrow]
- US practice of not declaring airport capacity limits (effectively using VMC capacities as targets) deserves careful scrutiny
- Very high cost of setting declared capacities at the wrong levels (or of not declaring any capacities at all)
  - may lead to excessive delay, schedule unreliability, negative environmental impacts
  - may lead to waste of capacity, undue anti-competitive restrictions on airline industry with large economic consequences